SERVICES AND CAPABILITIES

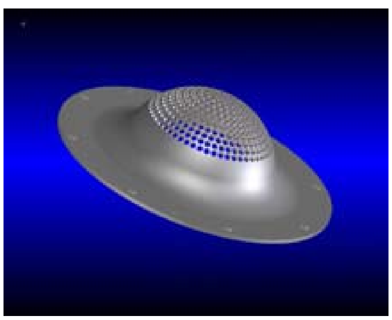
1. Rapid prototyping

What is rapid prototyping?

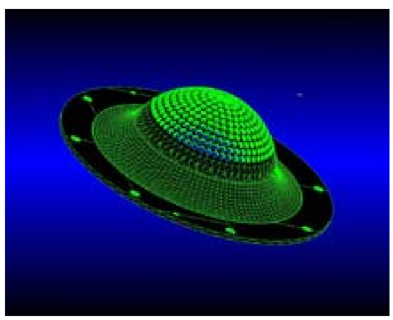
"Rapid prototyping" (RP) or more recently "Free Form Fabrication" refers to the fabrication of a physical, three-dimensional part of arbitrary shape directly from 3D computer-aided design (CAD) data. Unlike CNC machine tools, which are subtractive in nature, RP technology is an additive process that can generate free-form fabricated parts using powdered metals, polymers, paper, and other materials. Layer by layer, RP machines fabricate 3-dimensional objects based on thin horizontal cross sections taken from a computer model.

The process uses a numerical data set representing the 3D geometry such as a stereolithography file (.stl) to grow the part layer by layer. Each RP equipment supplier has proprietary software to orient, repair, and slice the geometry into layers for use in the equipment. Various RP processes use different manufacturing approaches with different materials.

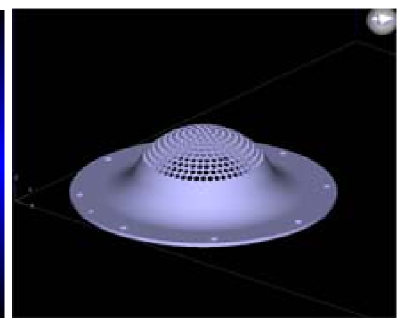
RP machines are used by manufacturers, designers, and researchers around the world for low-volume production, prototyping, and mold mastering. They are also used by scientists and surgeons for solid imaging, and by a few modern artists for innovative computerized sculpture.



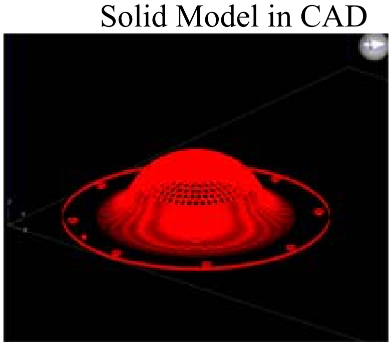
Solid Model in CAD



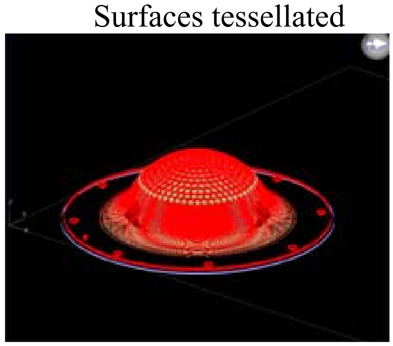
Surfaces tessellated



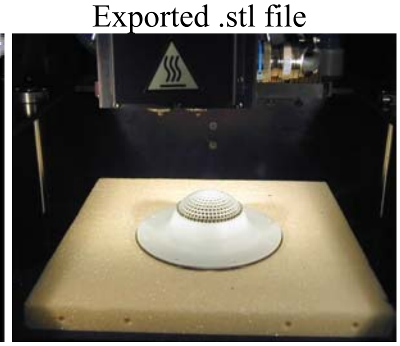
Exported .stl file



Sliced .stl file



Build file with supports



Model building

Finished physical model

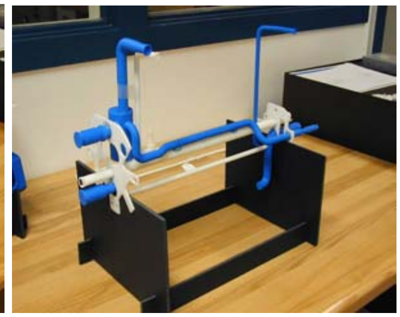
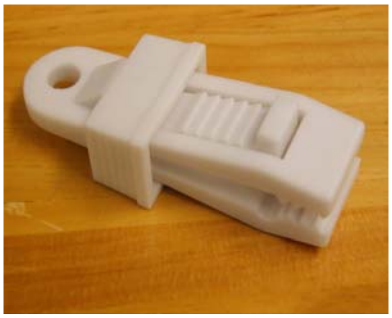
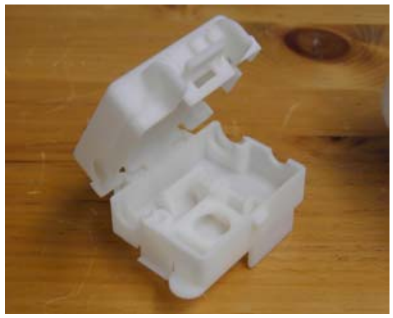
What capability does LBNL have?
Currently, DesignWorks has two rapid prototyping machines. The Fused Deposition Modeler (FDM®) is a patented rapid prototyping process by Stratasys™ Inc. The process extrudes a thermoplastic material and deposits it layer by layer to form solid three-dimensional parts.
The 3D systems™ Stereolithography machine (SL or SLA) uses a process that builds an object one layer at a time by curing photosensitive resin with a laser-generated beam of ultraviolet radiation. Originally applied to the technology of 3D Systems, the term "stereolithography" has broadened to include all technologies that process prototypes parts in this manner.

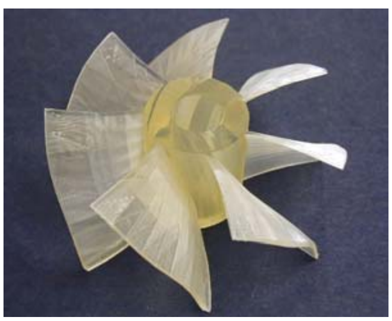


What kind of parts can the SLA and FDM make?
These machines generate 3-dimensional, solid objects you can hold in your hands, submit to testing, or assemble into working mechanisms. RP is ideally suited for parts of a complex nature that would be difficult or more time consuming to produce in a traditional manner such as CNC. Developers can increase the quality of their products by realizing, in the same amount of time, a larger number of variations on the objects envisioned by creative people working in CAD. Fabrication time for the layering process is mostly dependent on overall part volume and only slightly dependent on the level of part complexity. Comparatively, traditional machining is highly dependent on the complexity of the surface shapes and less dependent on overall part volume. For example, a 4-foot diameter circular plate would be much faster to fabricate using traditional fabrication techniques, but a replica of a mouse (computer or real) would be much faster to build using rapid prototyping. Indeed, rapid prototyping has been used to fabricate parts and replicate organic items that are impossible to build in any other fashion.
Although build volumes are generally smaller for RP machines, techniques such as scaling and building larger parts in smaller pieces may be used to compensate.







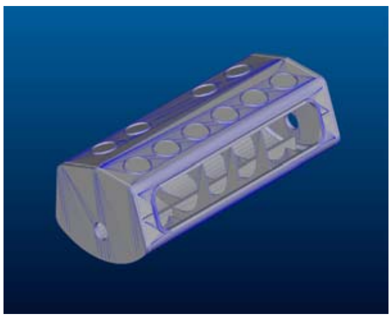
How long does it typically take to build a part?

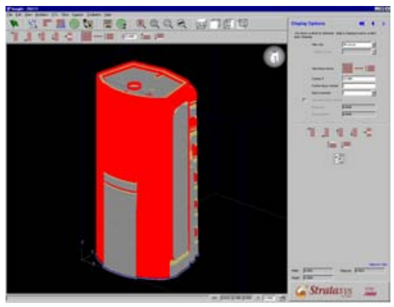
The SLA and FDM machines use different processes to produce parts. The time it takes to go from CAD to physical object is a bit longer for SLA due mainly to post processing of the object after it is built. However, the SLA part can produce smaller features with higher accuracy than the FDM.

The actual time to build parts ranges from hours to days based on the volume of the object. Parts can be combined in single build sessions to produce assemblies or accommodate different customers' parts at the same time. The FDM machine can also build "assembled" assemblies in a single build session.

I have a solid model on my computer; how do I get a part built?

The 3D CAD file is typically exported as an ".stl" file. The solid model surfaces are converted to a series of triangles. The conversion from CAD representation to triangles is called tessellation, which mathematically divides surfaces into planar facets or triangles. Pro/ENGINEER™, SolidDesigner™, SolidWorks™, and almost all other CAD programs have the ability to export this file type. There are settings that can be applied to the file prior to export that improve the quality of the final RP part. The preferred method is a Pro/ENGINEER ".prt" file. Contact Steve Dellinges in DesignWorks at extension x2539 to send the part over for a quote or if you have any questions about preparing CAD parts for rapid prototyping. We can consult with the customer as to which machine will be the best choice for the particular job.





What are the accuracies of RP parts?
Because "Free Form Fabrication" utilizes a layered process, there is no single answer to this question. Depending on the type of machine and materials utilized, "Z" layers are made as low as .0001" while the X and Y components are dictated by the laser spot size, droplet size, extrusion nozzle, photo mask, etc. For the FDM and SLA, see the feature list below for accuracy information. Generally, RP machines make parts from ± 0.001" to 0.005". Additionally, RP parts can be further machined after fabrication to higher specifications. There are processes being developed that can produce parts a small as 10µm.

What materials can RP parts be made of?
For the FDM and SLA, see the feature list below. Other RP technologies can make objects out of Metal, Ceramic, Paper, and Wax.

Features of the FDM (information from Stratasys):

- Material: ABS (colors)
  Investment Casting Wax
  Elastomer

Note: Polycarbonate and Sulphones materials are also available using Stratasys' new FDM Titan machine.

- Material properties (FDM 2000) ABS 400

Tensile Strength (psi) 5,000	Unnotched Impact (ft*lb./in) ---
Flexural Strength (psi) 9,500	Elongation (%): 50.00
Tensile Modulus (psi) 360,000	Hardness (Shore D): R105
Flexural Modulus (psi) 380,000	Softening Point (R&B) (F): 220
Notched Impact (ft*lb./in) 2.00	Specific Gravity (GMS/CM cu.): 1.05

- Build Envelope (in.): 10 X 10 X 10
- Achievable Accuracy: ± 0.005"
- Colors: Black, White, Blue, Red, Green, and Yellow.

Features of the SLA250 (information from 3D Systems):

- Material: A variety of Epoxy Resin and Acrylate Ester Blends
- Material properties (SLA 250/30) Liquid Photopolymer SL-5170

Tensile Strength (psi) 8,600 – 8,800	Unnotched Impact (ft*lb./in) ---
Flexural Strength (psi) 15,500 – 15,700	Elongation (%): 8.0
Tensile Modulus (KSI) 542 - 603	Hardness (Shore D): 85
Flexural Modulus (KSI) 423 - 436	Glass transition, Tg 65-90°C (184°F)
Notched Impact (ft*lb./in) 0.5 – 0.7	Specific Gravity (GMS/CM cu.): 1.22

- Build Envelope (in.): 10 X 10 X 10
- Natural color

Note: A new material called Stereocol® H-C 9100R is a specially formulated SL material for building 3-dimensional models with selectively colored areas for information visualization.

Mandible courtesy of Medical Modeling LLC